



# (Hypothetical) Center for Simulation Accident Environments and Event

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ASCI Academic Strategic Alliances Program  
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## Purpose of this presentation

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We will describe a class of centers (for accident environment and event simulation) that meet the ASAP statement and have goals/technology requirements/approaches that significantly overlap with ASCI safety goals/requirements/approaches.



## Elements Essential to ASCI Centers

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- Roadmap
- Technically broad problems that require an interdisciplinary approach
- Coupled physics
- Need for ASCI level computing
- Use of PSE to increase effectiveness



## ROADMAP: Center Goal

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This center will use simulation to make a probabilistic safety assessment of the consequences of transporting or storing complex electrical/chemical/mechanical “systems” containing explosive materials. Transportation can be by truck, airplane, train....; and “systems” can be oil tanks, armaments, gas bottles, batteries.....



## ROADMAP: Problem Description

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Serious questions exist about the safety of transporting potentially explosive or hazardous cargo on airplanes:

- regulations are not risk-based
- regulations do not consider interaction between various cargo
- containers not comprehensively tested
- testing of new containers is expensive and poses environmental threats.

A comprehensive simulation based approach is necessary to assess the safety of the transportation method and to assist with container design for safety.



## ROADMAP: One Accident Sequence (out of hundreds)

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- Crash of airplane
- Dispersal of cargo and airplane fuel
- Ignition of dispersed fuel
- Subjection of container to the fuel fire
- Response of cargo and container to fuel fire
- Triggering of cargo explosive
- Response of debris and surroundings to secondary explosions.



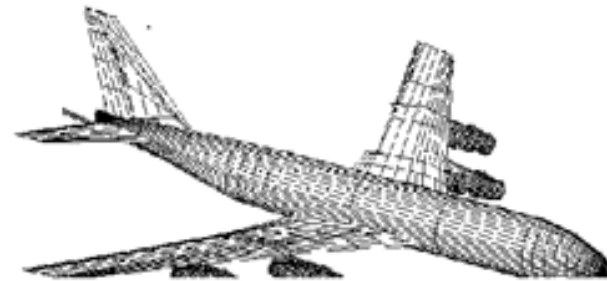
## ROADMAP: Crash of airplane (20ms)

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Issues: Determine if fuel tanks and cargo holds rupture

Simulation Requirements:

- Interaction between airplane and soil or pavement
- Material failure of airplane -- cracking and tearing of fuel tank
- Integration of aging effects in failure criteria
- Integration of manufacturing defects in failure criteria
- Resolution requirements in failure regions
- Mesh size/sub-domain integration





# ROADMAP: Dispersal of cargo and airplane fuel (1-2 seconds)

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Issues: Determine location of fuel, cargo and ignition sources

## Simulation Requirements:

- Fuel dispersal, pooling, splashing
- Cargo dispersal
- Damage of cargo containers: tearing, crushing, puncturing, dropping
- Damage of cargo/release of explosive or hazardous material
- Unintended electrical power or electrical discharge







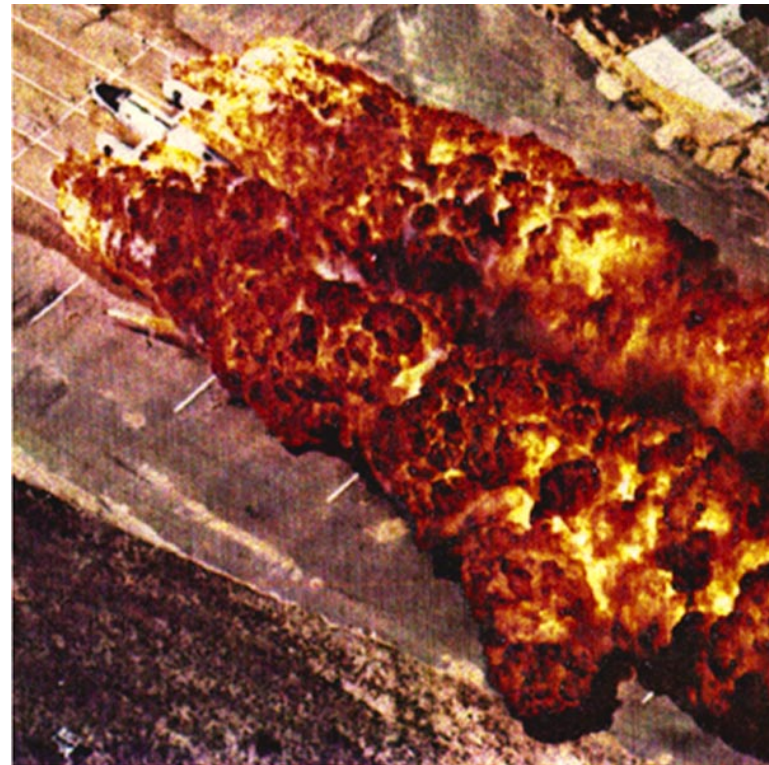
# ROADMAP: Ignition of dispersed fuel

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Issue: Will fuel ignite and where?

Simulation Requirements:

- Detonation/deflagration requirements for fuel, explosive material and combinations
- Integration of sub-grid models into large calculations
- Probabilistic treatment of ignition
- Coupled thermal/chemical calculations





# ROADMAP: Subjection of container to fuel fire

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Issue: Determine temperatures in cargo

Simulation Requirements:

- Fire Physics
  - combustion
  - participating media radiation
  - turbulence
  - object-fire interaction
  - fuel source
  - environment effects





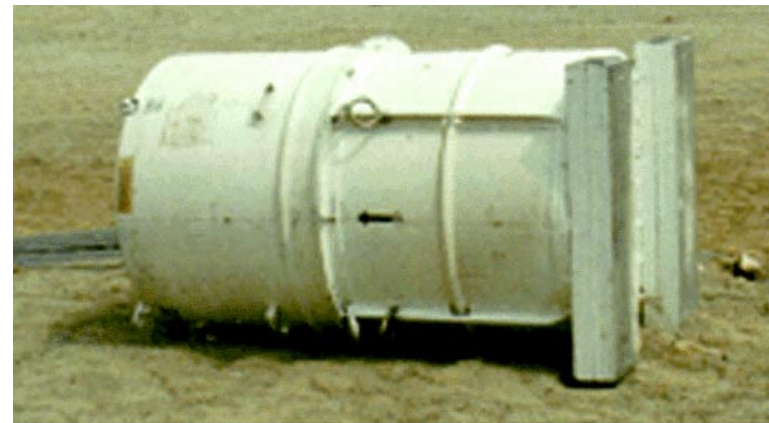
# ROADMAP: Response of cargo and container to fuel fire/ triggering of cargo explosive

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Issues: Fate of cargo

Simulation Requirements:

- Coupled thermal/chemical/mechanical processes:
  - material disintegration/buckling
  - deflagration to detonation criteria
  - response of aged/shocked explosive
  - object-fire interaction
  - shock physics





# ROADMAP: Response of debris and surroundings to secondary explosions

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Issue: Fate of cargo and surroundings, dispersal of hazardous material

## Simulation Requirements:

- description of secondary explosion and travel of shock front through (burning) debris and remaining airplane
- quasi-static mechanics  
determination of final configuration
- termination of fire.







# Computer Science/Computational/ Mathematical Issues

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- Adaptive -H & remesh
  - Multi-level/Multi-grid
  - parallel algorithm development for coupled mechanics
  - optimization techniques
  - non-deterministic techniques
  - uncertainty quantification
- for ASCI-scale simulations